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Autonomous Production of Propellants

K. Ramohalli and P. Schallhorn

Department of Aerospace and Mechanical Engineering

The University of Arizona

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Abstract

This research work deals with the autonomous production of propellants. Because, typically, 80% to 90% of a spacecraft's mass is propellants, it is advantageous to produce propellants in strategic locations en route to, and at, the desired mission destination. This will then reduce the weight of the spacecraft and the cost of each mission. Since one of the primary goals of the space program is safety, a totally automated propellant production system is therefore desirable. This system would thereby remove, from hostile, high-risk extraterrestrial environments, the constant human intervention currently required in the production of many propellants. This enables the exploration of space to be more than the search for and production of fuel. As a proof-of-concept demonstration, one specific case was chosen for this study, that of composite propellant processor; the principle is more important than the application, and the specific processor used saved SERC the considerable cost of acquiring a new liquid propellant processor that would also have required similar automation.

Background

Currently, most space propellant production is done with constant human intervention. Using a control room, man has total control over all aspects of the propellant production. This is fine on Earth, but it is too costly in space. Thus, the need for automated composite propellant production exists.

Approach

During the last year, we have completed testing on a heating system, which was designed by a graduate student (Paul Schallhorn), for the 1-pint mixer that is to be used for this project. Because propellant production requires mixing the ingredients at two constant temperatures (160 and 140°F), a self-contained water heating system is required for space-based operation. This system provides the required temperatures and only needs an electric power source to drive the pump motor and to heat the water in the heaters. This is not unrealistic, considering that electricity is also required for the mixer and controlling computer.

One approach, therefore, is to use a personal computer to control the introduction and mixing of the composite propellant ingredients (making sure that temperature is

constant on the walls of the bowl, detecting local "hot spots" within the mixture, and taking in-situ measurements of the viscosity of the mixture to check if it is within an acceptable range) in the mixer. Then, the mixture is pumped, via a computer program, into a cast, which will be placed into an oven for curing and then stored for future use.

#### Results to Date

The major results for 1989 are as follows:

1. During the spring of the year, the heating system for the propellant mixer was thoroughly tested for its ability to achieve the design requirements. The system not only achieved, but greatly exceeded these requirements. The system was able to maintain a negligible temperature drop across the bowl of the mixer (the 1°F temperature drop for which the system was designed had easily been reached). The temperature of the system was easily changed from 160°F to the required 140°F in a short amount of time, even without the aid of the computer. The automatic control work performed by Richard Wilson has allowed the system to easily maintain the required temperature within a ±2°F tolerance, with this tolerance continually decreasing.
2. An IBM PS/2 Model 80 was purchased for use on this project. This model has an Intel 80386 microprocessor operating at 20 MHz, a 115-megabyte hard disk drive, 4 megabytes of RAM, and a 1.44-megabyte 3.5-inch internal floppy disk drive. The computer was ordered with the following peripherals: a 14-inch VGA monitor, an 80387 math coprocessor, a 1200-baud internal modem, two 5.25-inch external diskette drives (360 Kb and 1.2 Mb), a mouse, and a Hewlett Packard Laserjet II printer. The computer arrived in January, and the peripherals arrived in early February. The computer system was operational by the middle of February. This computer system is also being used on various other SERC projects.
3. An Inframetrics infrared camera, Model 600L, has been purchased for this project. It will be used for direct surface temperature measurement of the propellant slurry. It will be mounted (not permanently) at the entrance of one of the mixer's view ports. It will eventually be integrated into the computer system for aiding the temperature control process of the automation.
4. A prototype hopper is currently being built for the injection of the propellant ingredients. This work is being done by undergraduate students under the supervision of Paul Schallhorn. This portion of the project has a projected completion date of May 1990. The hopper consists of a series of chambers containing the required ingredients, a means of weighing the solid ingredients, an

injection system for the liquid ingredients, a thermal jacket to preheat the ingredients, and a port to inject the ingredients.

5. An in-situ viscometer is being designed for placement within the mixing bowl. This would give more accurate viscosity measurements of the slurry at any point in time, and it is the only way in which an automated system could check for viscosity problems.

#### Summary

In summary, this task has shown that there is a need for automatic space-based production of propellants. We have also shown that there is no current system to produce composite propellants without human intervention. Work has begun on achieving this task. The heating system (previously designed) for a 1-pint vertical propellant mixer has been thoroughly tested. The result is that the heating system meets or exceeds the design criteria. A prototype hopper is being built for the injection of the required ingredients. It consists of a measuring system (for solid particles), a liquid injection system, a series of containers for the solid particles, a thermal jacket, and a delivery system. An IBM personal computer has been acquired. An Inframetrics infrared camera has been procured for temperature measurements of the propellant slurry. An in-situ measuring device is being developed for future integration in the system.

#### Participants

We would like to take this opportunity to thank Gary Hopkins and Milton Schick for their help in assembling and maintaining the entire system. We would also like to acknowledge Richard Wilson, who is doing the automatic controls portion of the heating system.